Net primary productivity of macrophyte communities after eight growing seasons in experimental planted and unplanted marshes

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Introduction

Direct measurements of macrophyte net primary productivity (NPP) were first made at the experimental wetland basins at the Olentangy River Wetland Research Park (ORWRP) in 1997. This study in 2001 represents the fifth set of such measurements. Before 1997 (the fourth growing season), harvesting was not considered a good option when vegetation was just getting started in the basins. By the fourth year (1997), we determined that limited harvesting of plants to estimate the productivity of the system was possible without affecting the general succession and productivity of the overall system.

Methods

Aboveground net primary productivity (NPP) was estimated by harvesting peak biomass at the end of the growing season (end of August 2001) at selected stations in the two experimental wetland basins at the ORWRP (Figure 1). The same stations established from the boardwalk system in 1997 (Mitsch and Bouchard, 1998) and used in 1998, 1999, and 2000 were visited again in 2001. To avoid harvesting the exact same spots, quadrats were not established at points were there had been harvesting in previous years. In each station, we used 1-m^2 quadrats to delineate the area of vegetation for harvest. When no vegetation was present, the station was skipped. Overall, there are potentially 22 stations in each wetland (increased by one in 2000 from previous years). Because of lack of vegetation in 2001, only 9 quadrats were sampled in each wetland, 7 out of 12 in the northern or inflow half of each basin and 2 out of 10 in the southern or outflow half of each basin. These low sample sizes were in response to the decreased plant coverage compared to previous years. In each quadrat, plants were clipped at ground level (the water was lowered in the wetlands to make sampling easier and to allow rapid recovery of the clipped plants). Samples were segregated both by quadrat and by species, placed in plastic bags and weighed in the field with a hanging balance (accuracy ± 40 g). Sub-samples were taken to the laboratory where both wet weight and dry weight (dried at 105°F for 48 hours) were determined to estimate dry/wet ratios. Average ratios for each species were multiplied by total wet weight of each species in a quadrat to estimate total dry weight production. The sum of all species in a quadrat was the estimated peak biomass and hence annual aboveground net primary productivity (NPP).

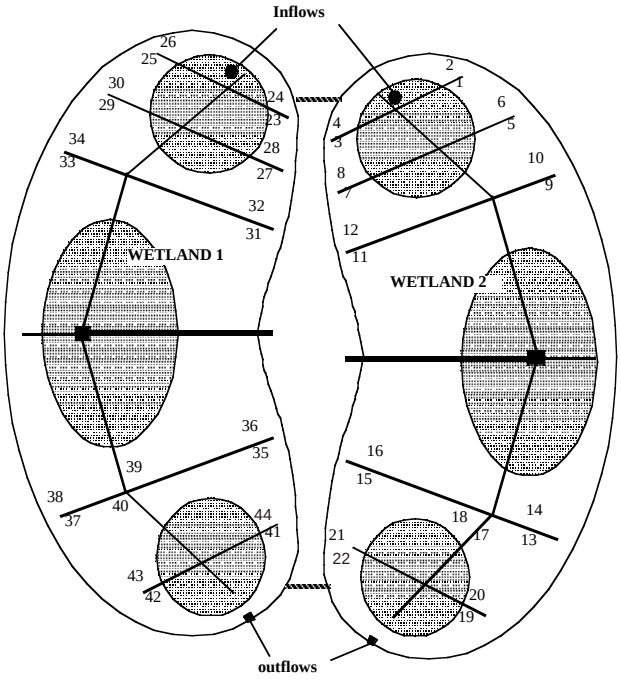

Figure 1. Sampling stations used for macrophyte harvesting, August 2001.

Results and Discussion

Comparison of Basins and Location

In 2001, macrophyte aboveground NPP was 393±87 g m^{-2} yr^{-1} in the planted Wetland 1 and 832±85 g m^{-2} yr^{-1} in the naturally colonizing Wetland 2 for the areas covered by macrophytes (Table 1). Productivity decreased by 18% in both Wetland 1 Wetland 2 from 2000 to 2001 (2000 rates: 482±64 g m^{-2} yr^{-1} in Wetland 1 and 1013±105 g m^{-2} yr^{-1} in Wetland 2 (Table 1)). Overall, macrophyte plot productivity continued to be statistically higher ($\alpha = 0.05$) in the colonizing Wetland 2 than in the planted Wetland 1 eight growing seasons after planting. The productivity at the outflow was numerically greater than the inflow for both Wetland 1 and Wetland 2, but neither difference was significant ($\alpha = 0.05$) (Figure 2).

Dry/wet Ratios

As in the previous annual reports, dry/wet ratios of individual plants which are necessary for estimating NPP are provided (Table 2). Dry/wet ratios ranged from 25-35% for *Schoenoplectus* over the past three years to 13-15% for *Sagittaria*, to 16-24% for *Sparganium*, and 20-31% for *Typha*.

Comparison with Previous Years

Overall, macrophyte NPP decreased in 2001 in both Wetland 1 and Wetland 2 (Figure 3). In 2000, NPP averaged 482 g m^{-2} y^{-1} in Wetland 1 and 1,013 g m^{-2} y^{-1} in Wetland 2. In 1999 NPP averaged 657 in Wetland 1 and 1,023 in Wetland 2. In 1998, NPP averaged 729 g m^{-2} y^{-1} in Wetland 1 and 1,127 g m^{-2} yr^{-1} in Wetland 2 for the areas covered by macrophytes (Figure 3). The productivity in Wetland 2 was significantly higher than the productivity of Wetland 1 (t-test, n=9, α=0.05). Overall, productivity per unit area in the last four years (1998-2001) has remained high and consistent in the naturally colonizing Wetland 2 because of the dominance of *Typha*. Productivity in Wetland 1, the planted wetland, has consistently dropped over the past four years to where it is now only 47% of the productivity of Wetland 2.

Species Dominating the Productivity

As was the case in 2000, the species harvested in the two basins indicate differences that are still attributable to the planting of 1994 (Figure 4), although these differences are less than in past years. Wetland 1, which was planted with 12 species in May 1994, has only one of those species still contributing significantly to macrophyte productivity *(Sparganium eurycarpum)*. This species represented 58% of the macrophyte aboveground productivity in the harvested quadrats in 2001. In comparison, this species plus *Schoenoplectus tabernaemontani* and *Sagittaria latifolia* represented 55% of the productivity in 2000 and these three species plus *Scirpus fluviatilis* represented 67% of the productivity in 1999 and 90% of the productivity in 1998. Of the introduced species, only *Sparganium* is still predominant in Wetland 1 in 2001.

Colonizing *Typha* provided the remaining 48% of the aboveground productivity in 2001 in Wetland 1. *Typha* contribution to the wetland NPP in the planted Wetland 1 was 33% in 2000 and 1999, 10% in 1998, and 14% in 1997, (Mitsch and Bouchard, 1998; Bouchard and Mitsch, 1999, 2000; Mitsch et al. 2001). *Typha* was found in 2 quadrats in Wetland 1, all in the inflow half of the wetland. It was found in 7 quadrats in 2000, 4 quadrats in 1999, 5 quadrants in 1998 and 7 quadrats in 1997. It had appeared to be losing dominance for several years until 2000 when it became a more important producer of biomass in Wetland 1. The opposite pattern appeared with *Sparganium* which decreased to 7 quadrats in 2001 in Wetland 1 after it was found in 8 quadrats in 2000, 11 quadrats in 1999, 9 quadrats in 1998 and 7 in 1997.

Table 1. Estimated net above-ground primary productivity (NAPP) of macrophyte communities in the Olentangy River experimental wetlands; from late August 1999 to 2001, based on peak biomass harvest. Numbers are ave±std error [# samples].

Wetland/ Year	Total NPP, g m^{-2} yr^{-1}	Inflow NPP, g m^{-2} yr^{-1}	Outflow NPP, g m^{-2} yr^{-1}
Wetland 1			
1999	657±76 [16]	601±126 [8]	714±90 [8]
2000	482±64 [16]	597±87 [8]	368±79 [8]
2001	393±87 [9]	454±98 [9]	181±120 [2]
Wetland 2			
1999	1023±94 [16]	790±75 [8]	1256±130 [8]
2000	1013±105 [16]	882±126 [8]	1144±163 [8]
2001	832±85 [9]	746±76 [9]	1134±145 [2]

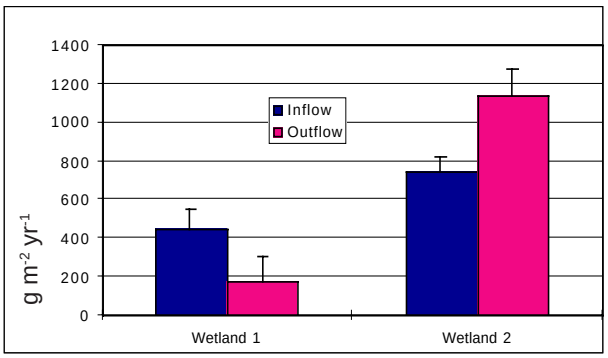

Figure 2. Aboveground net primary productivity in Wetland 1 and 2 in inflow and outflow areas for 2001.

Table 2. Dry/wet ratios (ave±std error (# samples)) of dominant macrophytes in the Olentangy River wetlands in 1999, 2000, and 2001.

Species/	Wetland 1	Wetland 2
Schoenoplectus tabernaemontani		
1999	0.35±0.01 (13)	0.33±0.01 (14)
2000	0.25±0.30 (6)	na
2001	na	na
Scirpus fluviatilis		
1999	0.30±0.01 (4)	na
2000	na	na
2001	na	na
Sagittaria latifolia		
1999	0.13±0.02 (4)	na
2000	0.15±0.07 (4)	na
2001	na	na
Sparganium eurycarpum		
1999	0.23±0.00 (11)	na
2000	0.24±0.07 (8)	na
2001	0.16±0.03 (7)	na
Typha spp.		
1999	0.26±0.00 (4)	0.26±0.01 (15)
2000	0.30±0.07 (7)	0.31±0.04 (16)
2001	0.20±0.05 (2)	0.29±0.03 (9)

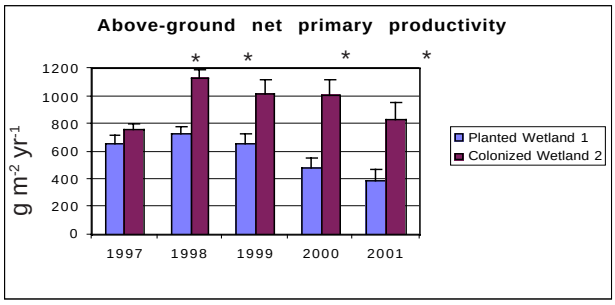

Figure 3. Aboveground net primary productivity for 1997-2001 in the experimental wetlands. * indicates significant differences between the two wetlands (α=0.05).

Only one taxa (*Typha* spp.) was found in the naturally colonizing Wetland 2. *Schoenoplectus tabernaemontani*, which contributed 19% of the productivity in Wetland 2 in 1999, and almost completely disappeared from Wetland 2 in 2000, was not seen in 2001. Between 1997 and 2000, a rapid increase of *Typha* dominance in Wetland 2 was observed. In 1997, *Typha* spp. contributed only 15% of the NPP; in 1998, it contributed up to 48% of the production; in 1999 it contributed 81% of the NPP; and in 2000 and 2001 it contributed 100%.

Autochthonous Carbon Sources from Macrophytes

Based on the aboveground productivity estimates and the estimates of vegetation cover presented elsewhere in this annual report (Mitsch and Zhang, 2002 in this annual report; W1 = 2,450 m^2; W2 = 1,502 m^2), aboveground productivity by macrophytes is an estimated 963 kg and 1250 kg per year in Wetlands 1 and 2 respectively. [This is calculated as the overall NPP in Table 1 multiplied by the "vegetation cover" in Mitsch and Zhang, 2002; this report]. These numbers are considerably lower than the 3300-3500 kg, 5800-6800 kg, and 1960-4265 in Wetland 1 and Wetland 2, respectively calculated for 1998, 1999, and 2000. Both the productivity per unit area and the overall macrophyte cover in the basins led to this decline in carbon sequestration in 2001.

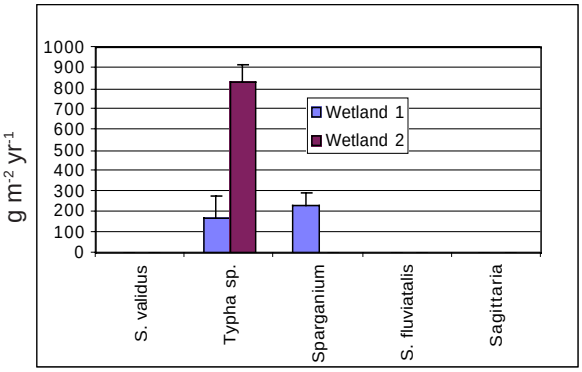

Figure 4. Distribution of peak biomass in August 2001 in the two experimental wetland basins.The 4 species other than *Typha* were planted in May 1994 in Wetland 1. Only *Sparganium eurycarpum* remains as *Schoenoplectus tabernaemontani* and *Scirpus fluviatilis* disappeared as dominant communities between 1999 and 2001. Wetland 2 was left as an unplanted control and was dominated by *Typha* in 2001.

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Appendix A. Harvested wet weight of plants in ORW experimental wetlands, August 2001. Station locations are shown in Figure 1. Weights are kg wet wt/m^2.

Station #	S. validus	Typha sp.	Sparganium	S. fluviatalis	Sagittaria	Total
Wetland 2						
1	0.0	1.02	0.0	0.0	0.0	1.02
2	0.0	0.81	0.0	0.0	0.0	0.81
3	skipped	skipped	skipped	skipped	skipped	skipped
4	0.0	0.51	0.0	0.0	0.0	0.51
5	0.0	0.89	0.0	0.0	0.0	0.89
6	0.0	0.58	0.0	0.0	0.0	0.58
7	skipped	skipped	skipped	skipped	skipped	skipped
8	0.0	0.88	0.0	0.0	0.0	0.88
9	0.0	0.54	0.0	0.0	0.0	0.54
10	skipped	skipped	skipped	skipped	skipped	skipped
11	skipped	skipped	skipped	skipped	skipped	skipped
12	skipped	skipped	skipped	skipped	skipped	skipped
13	skipped	skipped	skipped	skipped	skipped	skipped
14	0.0	1.28	0.0	0.0	0.0	1.28
15	0.0	0.99	0.0	0.0	0.0	0.99
16	skipped	skipped	skipped	skipped	skipped	skipped
17	skipped	skipped	skipped	skipped	skipped	skipped
18	skipped	skipped	skipped	skipped	skipped	skipped
19	skipped	skipped	skipped	skipped	skipped	skipped
20	skipped	skipped	skipped	skipped	skipped	skipped
21	skipped	skipped	skipped	skipped	skipped	skipped
22	skipped	skipped	skipped	skipped	skipped	skipped
TOTAL	0.0	7.49	0.0	0.0	0.0	7.49
AVERAGE	0.00	0.47	0.00	0.00	0.00	0.47
# OBSERV	9	9	9	9	9	9

Station #S. tabernaemontani		Typha sp.	Sparganium	S. fluviatalis	Sagittaria	Total
Wetland 1						
23	skipped	skipped	skipped	skipped	skipped	skipped
24	0.0	0.0	0.46	0.0	0.0	0.46
25	skipped	skipped	skipped	skipped	skipped	skipped
26	0.0	0.0	0.13	0.0	0.0	0.13
27	0.0	0.0	0.43	0.0	0.0	0.43
28	0.0	0.0	0.29	0.0	0.0	0.29
29	skipped	skipped	skipped	skipped	skipped	skipped
30	skipped	skipped	skipped	skipped	skipped	skipped
31	0.0	0.97	0.0	0.0	0.0	0.97
32	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.49	0.0	0.0	0.0	0.49
34	skipped	skipped	skipped	skipped	skipped	skipped
35	0.3	2.0	0.06	0.0	0.0	0.06
36	0.5	0.8	0.0	0.0	0.0	1.3
37	skipped	skipped	skipped	skipped	skipped	skipped
38	1.3	0.0	0.30	0.0	0.0	0.30
39	skipped	skipped	skipped	skipped	skipped	skipped
40	skipped	skipped	skipped	skipped	skipped	skipped
41	skipped	skipped	skipped	skipped	skipped	skipped
42	skipped	skipped	skipped	skipped	skipped	skipped
43	skipped	skipped	skipped	skipped	skipped	skipped
44	skipped	skipped	skipped	skipped	skipped	skipped
TOTAL	0.0	1.46	2.08	0.0	0.0	3.54
AVERAGE	0.0	0.09	0.13	0.0	0.0	0.39
# OBSERV	9	9	9	9	9	9

Appendix B. Laboratory-measured dry/wet ratios from sub-samples for species harvested in experimental wetlands in August 2001. *Schoenoplectus* = *Schoenoplectus tabernaemontani*; *S. fluviatalis* = *Scirpus fluviatalis*; *Sagittaria* = *Sagittaria latifolia*; *Sparganium* = *Sparganium eurycarpum*. Sampling stations (Stations) shown in Figure 1. Weights are in grams.

Wetland 1

St. #	Species	Wet	Dry	Dry/wet
24	Sparganium	333	44.3	0.133
26	Sparganium	247	49.4	0.200
27	Sparganium	558	78.4	0.141
28	Sparganium	306	38.4	0.125
35	Sparganium	423	61.0	0.144
32	Sparganium	301	48.5	0.161
38	Sparganium	405	81.5	0.201
31	Typha	441	101.9	0.231
33	Typha	315	50..9	0.162

Wetland 2

St.#	Species	Wet	Dry	Dry/wet
1	Typha	369	130.0	0.352
2	Typha	540	139.9	0.259
4	Typha	315	93.1	0.296
5	Typha	360	100.6	0.279
6	Typha	405	122.9	0.303
8	Typha	315	83.3	0.264
10	Typha	293	84.6	0.289
14	Typha	585	165.0	0.282
15	Typha	450	116.8	0.260